CS 678: Topics in Internet Research

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(Spring 2013)
Internet: A Success Story

- Internet has been an amazing success
  - It has changed the way we communicate, socialize and lead our lives

- Why did it become such a success?
  - What were the Internet design principles?
  - Do we need to rethink them?

- How would the future Internet look like?
What is this course about?

- **State of the art in networking research**
  - Emphasis on design principles

- **Understanding how to engage in networking research**
  - Paper readings and discussion

- **Investigating novel ideas through an independent, semester-long research project**
Some Projects From Last Year...

- “Low-Delay Transport Protocol for Data Centers: Can Least-Attained Service Help?”
  - Contributed towards our INFOCOM 2013 paper

- “Reliable Loss Differentiation in High Speed WiFi MACs”
  - Submissions to Hotnets 2012, INFOCOM 2013

- “Sizing Router Buffers: Impact of mean RTT estimates”
  - Under review at IEEE ICC 2013

- “Improving VoIP performance in Moving Vehicles by simultaneously using Edge/3G and WiFi”
Who should take this course?

- **Interest in computer networks**
  - State-of-the-art in networking research
  - Interest in carrying out research

- **Familiarity with networking concepts**
  - CS 382 - Network-Centric Computing
  - CS 471 - Computer Networks
Course Organization
Course Staff + Website

- **Dr. Zartash Afzal Uzmi**
  - Email: zartash@lums.edu.pk
  - SBASSE 9-319
  - Office hours:
    - Tue, Thu (after class), W (9:00-10:00am)

- **Dr. Ihsan Ayyub Qazi**
  - Email: ihsan.qazi@lums.edu.pk
  - SBASSE 9-114A
  - Office hours: 12pm-1pm (Tue/Thu)

- **Course website:** [http://chand.lums.edu.pk/cs678](http://chand.lums.edu.pk/cs678)
Grading Policy

- **Quizzes:** 10%
- **Attendance and Class Participation:** 10%
- **Paper Summaries + Short Presentations:** 10%
- **Long Presentations:** 5%
- **Final Exam:** 20%
- **Research Project:** 45%
Project Logistics

- **Research Project:** 45%
  - Biweekly Progress Meetings: 10%
  - Project Proposal: 5%
  - Contributions/Report: 15%
  - Completion/Presentation: 10%
  - Consulting Reports: 5%

- **At most 2 students per group**

- **Finalize your group as soon as possible**
Proposal Logistics (Cont.)

- **Project Proposal**
  - Due on February 12\textsuperscript{th} in the form of a 1-page written document
  - Motivation, Key Problem, and Literature Survey
  - 10-min presentation on the proposal
Paper Summaries

- **Written summary (max 1-page) of each paper**
  - Due by 11:59pm the night before the lecture

- **Submission on LMS, Discussion on Piazza**
  - [https://piazza.com/lums.edu.pk/spring2013/cs678/](https://piazza.com/lums.edu.pk/spring2013/cs678/)

- **Summaries should cover the following aspects**
  - Main idea, Key assumptions, Critique
  - Advantage not discussed in the paper
  - Possible Extension/Improvements
Long Presentations

- 2-3 15 min presentations during the semester
  - At most 7 slides

- You will be assigned papers randomly

- Be prepared to answer any questions
Short Presentations

- Short (max 5 min) oral summary of the paper at the start of a class
  - Problem addressed by the paper
  - Solution approach
  - Critique

- Students will be chosen randomly 😊
  - Generally 1-2 in each class
Class Participation (CP)

- Important in a reading/discussion course

- So participate actively in class
  - Ask questions
  - Criticize ideas
  - Propose ideas, etc

- Grading of CP will also include attendance
Consulting Reports

- Students will evaluate other projects
  - Evaluation expected 3 times in the semester

- Here are the timelines:
  - After Project Proposal Submission
    - 15th February, Half-page report
  - Before Midterm Exams
    - 8th March, Half-page report
  - After Final Project Report
    - 8th May, Half-page report
Quizzes

- Based on assigned readings for the class
  - Quizzes will be unannounced
Final Exam

- Based on the papers read in the course
  - Focus on basic ideas in the papers

- Open papers/notes
  - No need to worry 😊
How to read a research paper efficiently?
How to Read a Paper?

- Researchers spend a lot of time reading papers
  - Efficient reading can considerably reduce the time spent
- [1] proposes a three-pass method
  - **Pass 1**: Title, Abstract, Intro, Section titles, Conclusion
    - **Goal**: “Get the Big-Picture”, **Time** ~5-10 mins
    - **Category, Context, Correctness, Contributions, Clarity**
  - **Pass 2**: Read carefully (incl. figures, refs) but ignore proofs
    - **Goal**: Grasp content of the paper, **Time** <1hr
    - Be able to summarize to other with supporting evidence
  - **Pass 3**: Virtually re-implement the paper
    - **Goal**: Identify key innovations and any hidden failings and assumptions, **Time** ~1-4 hrs

Doing a Literature Survey

- Paper reading is put to test when doing a survey
- **Three-pass approach**
  - **Pass 1:** Use search engines like 'Google Scholar' or 'CiteSeet'
    - Use some well-chosen key words to find 5 recent papers in the area
    - Do one pass on each paper and go through the related work section
    - If you find a survey paper, your are done!

  - **Pass 2:** Otherwise, find shared citations and repeated authors
    - These are the key papers and researchers in the area
    - Download papers, visit the website of researchers

  - **Pass 3:** Go over the recent proceedings of top conferences
    - A quick scan will help you identify the recent high-quality work
    - These (+ Pass 1/Pass 2 papers) are the first version of your survey
    - Read them, if they cite a paper you didn’t find earlier, read as needed
Topics

- Network Architectures and Principles
- Congestion Control and Buffer Sizing
- Routing and Router Scalability
- Cloud Computing and Data Centers
- Wireless Networks
Research Topics
Network Architectures and Principles
What is a network architecture?

- **Set of design principles for organizing network functionality**
- **Internet architecture**
  - **Organized into layers**
    - A lower layer provides service to higher layers
    - Information about lower layers
  - **Thin waist**
    - Enabled innovation above and below
    - Hard to make changes to IP
  - **Focus on host-to-host communication**
    - Most communication is no longer host-to-host
- **Many new challenges**: Security, Privacy, Mobility, Wireless, etc.
How should the Internet architecture look like in 15 years?

- If we were to design it from scratch, how would we do it?
- Should it be clean slate or evolutionary?
- What design principles should it follow?
  - All aspects are being debated hotly
- Many proposed architectures
  - CCN, XIA, Named Data Networking, MobilityFirst, NEBULA, SDN/OpenFlow,...
Papers in this research area...

- Will help us **understand** the key design principles of the Internet Architecture
  - We will **brainstorm** their relevance today

- We will read about **new Internet architecture proposals**
  - Their strengths and limitations

- Will help us appreciate what a future Internet architecture might look like
Congestion Control and Buffer Sizing
Q. Congestion Control: How do we allocate resources (link bandwidth + buffers) so as to prevent congestion and achieve efficient and fair bandwidth allocations?

Q. Buffer Sizing: How much buffers should a router have in order to maintain high link utilization, low delay, and low loss rate?
Congestion Control and Buffer Sizing

- We will understand the key principles behind designing congestion control protocols.

- We will understand how buffer sizing impacts the performance of applications.
  - Often there is no one answer.
  - Depends on applications (delay vs throughput sensitive) and transport protocols.
Routing and Router Scalability
Router Scalability

- Game of Time and Space

- Time
  - How fast can you lookup?
  - How fast can you copy from IN to OUT?

- Space
  - How much storage is needed?
  - Global routing table size!
Cloud Computing and Data Centers
Cloud Computing

- Online services becoming extremely popular
- Hosted in large data centers
  - 100,000+ servers
Google Oregon Datacenter
Data Centers

- Data center networks have unique characteristics
  - Partition/aggregate workflow pattern
    - Synchronized responses
  - Very high bandwidth and micro-second latencies
  - Huge power consumer

- Gives rise to unique challenges

- Many interesting questions still unanswered
  - What is the best QoS model for data centers?
  - How can we do network diagnosis?
Research Questions

- How can we minimize response times?
  - Amazon: 100ms latency cost 1% profit
  - Google: Extra 500ms latency dropped traffic by 20%

- How to enable high efficiency + resilience?
  - High efficiency: Admit large number of clients
  - Resilience: Fault tolerance
Wireless Networks
Wireless Networks

- **Becoming increasingly ubiquitous**
  - Offices, homes, cafes, airports, etc

- **Challenges**
  - *Wireless Spectrum is a scarce resource*
    - Important to use it efficiently
  - *Interference Management*
    - Wireless is broadcast, more density often implies higher interference
High Speed Wireless

802.11b ➞ 11Mbps
802.11a/g ➞ 54Mbps
802.11n ➞ 600Mbps
802.11ac ➞ 1-4Gbps
802.11ad ➞ 7Gbps

➢ Inefficient access mechanisms
  o WiFi MAC efficiency degrades with speed
  o How to design efficient WiFi protocols?
Research Questions

- WiFi Inefficiency
- Wireless loss differentiation
- Long-distance WiFi
Research Project

- Project ideas will be introduced soon

- You can choose one of the projects from the list or propose your own
  - Important to discuss with the instructors before the proposal
Some Resources

- ACM Digital Library
- IEEE Explore
- LUMS has subscription for the above resources

Some Networking Conferences
  - ACM SIGCOMM, INFOCOM, MOBICOM, CoNEXT, NSDI, ICNP, ICC

Some Measurement Conferences
  - IMC, PAM
Evaluating Ideas

- **Simulations**
  - **NS2** (Most widely used, has a lot of support)
  - **NS3** (New, not backward compatible, less support)

- **Testbed**
  - **Emulab** (*Wired + 802.11 + USRP + Sensor Motes*)
  - **Planetlab** (*wired, all over the world*)
  - **GENI** (*Wired + Wireless + WiMax + OpenFlow*)

- We has some 802.11n WiFi cards and router boards available for experimentation

- If you need anything for experimentation, talk to us
Thank you!